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Workplace Relations, Skills-Training and Technological Change at Plant-Level

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Résumé de l'article

Cet article étudie d'un point de vue critique les relations en milieu de travail, la formation professionnelle et les changements technologiques en se demandant s'ils sont nécessairement reliés les uns aux autres d'une manière rigoureuse, spécialement lorsqu'il s'agit de microélectronique. Il soutient aussi que de nouveaux métiers apparaissent là où la technologie et des marches différenciées agissent les uns sur les autres, ce qui a d'importantes conséquences sur les stratégies de formation professionnelle.

Les recherches sur lesquelles il repose se fondent sur un échantillon considérable d'entreprises britanniques dans les secteurs de haute technologie. Ces entreprises recourent à la microélectronique à des degrés divers. Les entrevues ont été effectuées auprès du personnel d'ingénieurs et des responsables de la formation.

L'avènement de la microélectronique dans la fabrication des produits dérivés de l'ingénierie a coïncidé avec une crise dans les marchés des biens et une tendance plus accentuée de la consommation ou de l'achalandage qui a accompagné une plus grande automatisation. Cela a entraîné des progrès comme l'esthétique industrielle (design) qui ont eu comme conséquence de rendre plus complexes tant l'esthétique industrielle que le produit. Aussi a-t-on vu dans la technologie nouvelle un amalgame des deux fonctions qui, grâce à l'automatisation du « design » qui rend la production en petits lots ou en petite quantité plus proche de la production de masse de façon à réduire les coûts par l'intermédiaire d'une spécialisation souple. Une des contraintes majeures des entreprises britanniques a été le manque de compétence dans ce domaine. Trop d'entreprises ont tenté d'engager des diplômés d'université plutôt que de recycler les techniciens déjà à leur service. Le recyclage des diplômés était aussi important. On a découvert que l'utilisation plus considérable de systèmes plus compliqués exigeait des ingénieurs polyvalents et des travailleurs davantage conscients de la qualité du produit.

Les auteurs soutiennent ensuite que l'éducation continue et la formation professionnelle sont nécessaires pour recueillir les avantages de la microélectronique. Les auteurs ont poursuivi leurs recherches de manière à en voir l'impact sur les compétences pour conclure que les théories tendant à diminuer la qualification professionnelle (de-skilling) sont d'une approche trop simpliste, tout autant que le mirage d'une usine totalement automatisée où il n'y a pas de travailleurs. Ce qui peut se produire relativement à la qualification professionnelle est le résultat d'un processus politique en milieu de travail par les progrès et les reculs des dirigeants et des travailleurs pour exercer le contrôle.

L'article étudie les liens entre la technologie et la division du travail, ce qui amène les auteurs à considérer que les qualifications professionnelles sont rehaussées plutôt que diminuées par suite des progrès de la spécialisation flexible et de la technologie. En Grande-Bretagne, certaines entreprises ont eu tendance à réduire les qualifications, mais la volonté de faire une trouée dans des marches différenciées a conduit les entreprises progressives à recourir aux travailleurs qualifiés lorsque la qualité plutôt que le niveau des prix devient de première importance.

Le niveau de qualification moyen dans les usines peut s'être élevée, mais ceci s'est produit aux dépens des travailleurs moins qualifiés et signifie qu'il se trouve plus de personnes à l'usine dans les catégories de postes de haute qualification. L'article analyse également les conséquences que cette situation peut avoir sur le syndicalisme. Les syndicats réagissent et ces réactions consistent à se demander si les emplois de leurs membres sont menacés ou augmentés. Enfin, un programme en six étapes relatif aux changements en matière de technologie et de qualification a été mis au point pour le milieu de travail de façon à relier les marches, la consommation et la différenciation avec des qualifications polyvalentes ou hybrides pour les mêmes travailleurs, les coûts de réadaptation professionnelle et le recrutement du personnel.

L'article traite finalement de l'effet qui peut résulter de ces transformations sur les emplois semi-qualifiés et sur l'augmentation du nombre d'hommes de métier et de techniciens qui ont une formation à plusieurs volets. Une forme plus souple d'organisation du travail peut accompagner la situation nouvelle par l'introduction de groupes de travail et de structures qui peuvent servir de modèles. Les disciplines de formation professionnelle peuvent devenir plus interreliées et intégrées. En conséquence, le rôle de la fonction de formation devient aussi plus important.

La conclusion que l'on peut tirer de cette enquête à l'échelle nationale vise à montrer jusqu'à quel point ces tendances s'appliquent à diverses sociétés avancées et si les formes d'organisation en milieu de travail reposent sur des bases culturelles plutôt que déterministes dans les économies post-industrielles.

Workplace Relations, Skills-Training and Technological Change at Plant-Level

Adrian Campbell
and
Malcolm Warner

This paper critically looks at workplace relations, skills-training and technological change and asks whether they are necessarily linked together in an inflexible way, particularly where microelectronics applications are concerned. It then goes on to argue that 'automation' can lead to the re-assembly of skills where mass-markets become differentiated at saturated levels of demand, with important implications for training-strategies.

Simple conceptions of linear social change or, indeed, progress have been on the retreat since and end of the nineteenth century, and most particularly in the first half of the twentieth, with developments in 'pure science' contributing to the collapse. However, with the post-war era, the idea of progress through technology did enjoy something of an intellectual renaissance. With the onset of the 'crisis of mass production' (Piore & Sabel, 1984) in the 1970's, coinciding with the appearance of the 'micro-chip', a different idea has acquired common currency, that of progress through technological revolution, in this case the 'microelectronics revolution' (Forester, 1980). If not the steady, uphill climb of the traditional linear theorists, then we are presented with a more awesome progression through various phases of turmoil arriving at a bright future. The 'third wave' approach conveys an almost Hegelian delight in presenting us with the giant, unseen forces that are overturning the familiar with the unknown.

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Others have been more cautious. For example, an earlier study involving one of the present co-authors, whilst not denying the enormity of the changes involved, stressed the continuity of the process by pointing out that «one finds analyses of new technology as the 'second', 'third', or whichever 'industrial revolution', the 'information revolution' and so on». (Sorge *et al*, 1983).

The slogans of the 'information revolution', have led to a neglect of the more traditional skills to which information technology is to be applied, and a neglect of manufacturing in favour of services. In Britain particularly, the jargon of the revolution has acted as a veritable smokescreen behind which 'old industries' and manufacturing in general have withered. While it is true that in all the major industrialised countries, there has been a *relative* decline of manufacturing compared with services (a shift which has been in progress on a large scale since the 1960's), only in Britain has manufacturing gone into *absolute* decline. It may however be a trend which reflects weaknesses in the economy and may have nothing directly to do with the information revolution *per se*.

Although the permanent revolution/evolution outlook noted above, avoids the simplification inherent in seeing information technology as representing a clear break with the past, and fits neatly with the Schumpeterian (1961) conception of constant change being the *status quo* of capitalism, it seems perhaps a little too sanguine on reflection. King (1982) points out that the replacement of workers by machines was expected by some to lead to extensive unemployment and intensive misery, whereas in fact the reverse happened (in the long-run). There are, however, no grounds for assuming that the same will occur with microelectronics or for that matter, for assuming that there will necessarily be a difference, unless we take on board the idea that there is a critical point beyond which increases in productivity will no longer translate into jobs. Evidence that this may be occurring, in manufacturing at least, can be provided by the British economic 'recovery', whereby in the last 3-4 years increases in productivity and in profits have not been accompanied by proportionate increases in employment in the companies concerned.

CURRENT RESEARCH

One of the concerns in our current research (Campbell & Warner, 1986) is the extent to which even within the traditional area of work, something approaching *continuous education and training* may be essential, if any kind of continuity or competitive advantage is not to be lost. If there is a difference between microelectronics and earlier innovations, it is the

speed with which the change works, producing the constantly plunging real cost of computing equipment. It is an open question whether or not the communication technologies associated with microelectronics themselves will enable people and institutions to adapt at the speed which appears to be required. To assume this is to take as given some kind of correspondence between the level of technical/sophistication available to a society, and the level of the 'quality of life' in that society. Schaff neatly expresses the ideology of progress through technology thus: «except as a result of great disasters, nothing moves backward in history. We have to move forward, that is to new, higher forms of activity» (1982; p. 344).

The idea that technology through 'automation' removes menial tasks and favours the 'higher' occupations is an established one. The occupational profiles of the British companies (see Table 1) covered to date in our ongoing investigation of new technology, innovation and training (Campbell and Warner, 1987b) certainly provide evidence for this observation, although company strategies may have more input into the process than is sometimes supposed.

The cases investigated so far are listed below, noting their major products. The sample consisted of 26 British firms divided into three groups based on their size. There were establishments in each of the categories, namely small, medium and large, as measured by the number of people employed in the units involved (see Table 1). The cases were mostly located in the South of England and the Midlands. The bands were up to 200, up to 1 000 and over 1 000 employees. The firms were also selected to cover a range of products which used microelectronics devices in varying degrees of technological complexity. Interviews were carried out for the most part on each site with the engineering personnel and training managers involved (see Campbell and Warner 1987a).

The results of the British study reveal the following picture. The introduction of microelectronics into engineering products coincided with a crisis regarding mass-production markets, which has led to a greater degree of competition and an increase in customer expectations. The trend towards customization draws both on these events and also on the increased automation that has occurred in design, through the use of Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) to enable 'repeats' and modifications. These developments in turn have facilitated a greater emphasis on design rather than production-capability, with design and production becoming increasingly separate activities in many cases. As with all the findings of the study, counter-trends were found to be in force — the new developments, particularly in small-batch or unit production, could mean a merging of the two functions. While the small-batch production entails a

greater emphasis on skills than the traditions of British manufacturing is geared to, developments in product technology and in design automation are being geared to make customised production more akin to mass-production, in order to reduce costs. The availability of key skills, particularly in the electronics area appears to have become a major constraint on companies. In general, the companies were considered to place too much emphasis on graduate recruitment rather than the training of technicians to fill the same roles, which could often be to their longer-term advantage. Graduate re-training, in the light of the speed of technological developments also needs to be expanded. In these respects popular conceptions of the skill-shortage have been simplistic. It was also found that the increased overall complexity of technical systems, as opposed to the structure of their component parts, which has in many cases been simplified through micro-electrics applications has led to a need for more broadly-trained hybrid engineers with a high level of product awareness.

Table 1
Major Product Areas and Plant Size of Organisations Studied

<i>Case no.</i>	<i>Major Product Areas</i>	<i>Plant Size</i>
1	Industrial measurement	M
2	Controls and communications	L
3	Circuit plating lines	S
4	Office automation	M
5	Aeronautics	L
6	CAD systems	S
7	Industrial measurement	S
8	Audio-visual services	M
9	Aeronautics	L
10	Battlefield communications	M
11	Microtesting	S
12	Closed-circuit and video	S
13	Chemical analysers	S
14	Monitoring systems	L
15	Flight controls	M
16	Mechanical engineering	L
17	Semi-conductor testing systems	M
18	Conference systems	S
19	Computer systems	L
20	Communications	M
21	Customized computer systems	S
22	Control and monitoring systems	M
23	Reprographics	L
24	Mechanical control systems	M
25	Industrial measurement	L
26	Controls and communications	L

DESKILLING AND AUTOMATION

Wilkinson (1983), for one, has won praise for criticising the disingenuousness of the 'innovation-centred' approach, while keeping a safe distance from the unstoppable steamroller of de-skilling envisaged by Braverman (1974). The former describes the ways in which attempts to marginalise skilled workers in the production process lead to inefficiency and can be foiled by judicious intervention from these workers into the 'automated' process. Both the de-skilling and automation impact theorists tend to be concentrated in the Anglo-Saxon cultures where Taylorism in mass-production may be said to have its strongest roots, although it of course spread to many other national settings (see Merkle, 1980). As Sorge *et al* (1983) and Senker & Beesley (1986) have argued, approaches to automation in these countries have been led along by a vision of the 'workerless factory' which, although based on an extrapolation of current trends, is ultimately misleading. As cited, Wilkinson's (1983) examples also demonstrate this. As we have said, the marginalization of skilled labour, and the obstacles placed in the way of their intervening in the process, lead to inefficiency. The larger problem, which Wilkinson does not emphasise so much, is that the position cannot be remedied through a kind of 'push and pull' between management and workforce over control in the plant.

If management are convinced that worker-involvement in the process is either undesirable, unnecessary or both, they will no longer train people to fulfill those functions and the skills will leave the job as those who worked on the process before automation eventually pass on. Again, it is also possible to argue that although management will usually try to run automated plant with the least skill possible on the part of operators, they will soon be forced by bad results to bring the skills back onto the shop-floor. This may not occur before it is too late.

Our own ongoing research (see Campbell & Warner, 1986) suggests to us that beneath the specificities of workplace power-struggles and strategies something resembling a 'pendulum movement' operates regarding technology and skills. The further one trend is advanced, the stronger the counter-trends that gather against it. One simple illustration could be that the more employment in some parts of industry becomes a matter of high qualifications and creative work (this is true in some areas), the more other forms of employment in industry or in the service-sector resemble unskilled drudgery. We would emphasise that the impermanence of the movement *in either direction* differentiates it from the existing concept of 'skill polarization'.

TECHNOLOGY AND THE DIVISION OF LABOUR

Recent work by Piore and Sabel (1984) has detailed how the crisis of mass markets has been solved (in some regions at least) by the application of what they term 'flexible specialization', with short production-runs and customization, and competition on grounds other than price (though not excluding it). For this to occur on a large scale, certain technical preconditions are necessary. Computers and microprocessors in general are seen as a major source of the required flexibility in manufacturing: «With conventional technology, this adaptation is done by physical adjustments in the equipment; whenever the product is changed, the specialized machine must be re-built. In craft production this means changing tools and the fixture that position the workpiece during machining. With computer technology, the equipment (the hardware) is adapted to the operation by the computer program (the software); therefore, the equipment can be put to new uses without physical adjustments simply by re-programming» (1984; p. 260).

Likewise Altshuler *et al* have noted, apropos the automobile industry that «New production hardware is already lowering the minimum efficient annual manufacturing scale for individual product lines and will lower it in the future... new hardware on the plant floor, in combination with computer-aided design, engineering and tooling, is reducing the total number of units of a given model that must be produced over its production life in order to recoup development costs... scale requirements in general are no longer the driving force for industry concentration that they have been in the past» (1984; p. 182).

In the domain of industrial sociology, it has already been noted that: the «previous logic of socio-technical design has been geared to specialized homogenous mass markets (based on) inflexible automation, an erosion of craft worker skills, and increased emphasis on separate planning activities» (Sorge *et al*, 1983; p. 158). This *status quo* is increasingly threatened, or at least questioned, as small-batch production becomes viable at something nearer to mass production levels.

Insofar as these observations are true, then the technology/skills matrix has, in some industries and regions at least, some 'full-circle' since Adam Smith's time (see table 2). Although potential flexible technologies had existed for some time without being taken up by mass production business, since in the prevailing market conditions they were seen inappropriate (Piore and Sabel, 1984; p. 258), there can be little doubt that the advent of the 'micro-chip' had a resonance far beyond the conditions which influenced its take-up by different industries (in any case it was generally seen as a labour-saving device for mass production at the start).

Table 2
Classification of Technological Stages
 (see Warner 1987)

	<i>Mode of Organization</i>	<i>Flow Production</i>	<i>Technology</i>	<i>Division of Labour</i>	<i>Product</i>	<i>Market</i>
I	Small Workshop	Absent	Flexible	Low	Customized	Differentiated
II	Early Factory	Nascent	Rel. Flexible	Medium	Rel. Standardized	Rel. Differentiated
III	Modern Factory	Present	Rel. Inflexible	High	Standardized	Homogeneous
IV	Automated Plant	Modified	Flexible	Modified	Rel. Customized	Differentiated
V	Manufacturing Cells	Responsive	Flexible	Negotiated	Customized	Rapidly Changing

The microprocessor thus seems reminiscent of the steam-hammer observed by Karl Marx «it is mere child's play for it to crush a block of granite to powder, yet it is no less capable of driving, with a succession of light taps, a nail into a piece of soft wood» (1867; p. 382). The quasi-religious tone in which the flexibility of key technical innovations are described, then as now, emphasises the ease with which it is possible to lapse into technological messianism. However, the impact of the microprocessor, changing as well as relecting its context, leads us to regard it as a 'prime mover' of industrial and social change. At first sight, Adam Smith's (1776) observation that the division of labour is constrained by the extent of the market' could easily read 'the extent of the market is constrained by the division of labour' and be no less accurate. If, however, the statement is interpreted as placing the emphasis on the market as the prime mover, the experience of microelectronics would augur against it. Time and again in the cases observed in our ongoing research investigation, the new technical possibilities opened up by microelectronic product applications were said to act as a stimulus to customer demands, rather than the reverse. Technology thus emerges as the prime mover, in this sense at least (c.f. Child, 1972; Clegg and Dunkerly, 1980).

One of the problems confronting this analysis is that in the 1980's a high level of automation and flexibility have accompanied a differentiation of the market, which in turn has accompanied a recession reflecting contracting aggregate demand-levels. On the surface, it would be possible to argue that the differentiation of the market is a simple result of the recession. A slackening demand may be seen as placing the individual consumer or group of consumers in a stronger position, from which they

are able to demand more specific goods for their money. On the other hand, the recession and the differentiation of the market could both be seen as results of or responses to the various phenomena of the 1970's already referred to — namely, market saturation, crisis in the supply of raw materials, more international competition, and so on.

If we risk a simplification and take differentiation and recession as twin (but separate) repercussions of a larger crisis of mass production, we may then disentangle two distinct brands of 'automation' that have been accelerated in recent years. On the one hand, tighter international competition leads to a drive to cut production-costs purely and simply, through automating particular jobs. On the other, 'automation' has been applied to enable greater flexibility of production and has been accompanied by a more thoroughgoing change of direction regarding skills in many cases. Although both forms appear to involve a reduction in direct labour (and sometimes indirect, though not in the same proportion), in the first the accent is on the wholesale elimination of labour, whereas in the latter it is more on the deployment of labour.

The difference is significant. In Britain, traditionally, there has been too great an emphasis *on price as the basis for competition*, and consequently a preoccupation with the first form of 'automation'. British firms have often installed new technology with often little consideration for the level of skills or training required under the new system, assuming technology to be de-skilling by definition. Frequently, companies have attempted to run new equipment with less skilled labour, laying off those who had previously worked the process. Only later, under pressure of breakdowns and poor quality, have they relented and brought the original workers back. The assumption that higher technology equals less skill (and that this constitutes the main reason for introducing it) works even with the technologies that only have real value when employed for purposes of flexibility throughout the system. Computer-Aided Design (CAD) is an example of this, where reduction in drawing-office labour costs is still all too often seen as the only justification for implementation by senior British managements.

THE CREATION OF NEW SKILLS

The difference between these two types of 'automation' has implications for our view of the division of labour. Adam Smith linked the division of labour to productivity — it was therefore a function of technology, or rather *vice versa*; the division of labour leads to «intervention of a great number of machines which facilitate and abridge labour, and enable one

man to do the work of many» (1776; p. 7). Machines were introduced as a result of the already existing division, the extent to which the latter existed depending on the extent of the market. This process of replacing human by mechanical functions opened the way to rendering the operative as it were, an adjunct of the machine. At the same time, Smith saw positive skill-returns from the division of labour; «the greatest improvement in the productive powers of labour and the greater part of the skill, dexterity, and judgement with which it is anywhere directed, or applied, seem to have been the effects of division of labour» (1776; p. 4). This reiterates for us the twin-phenomena we earlier noted concerning skill polarization — in effect, the co-existence of de-skilling with the growth of specialist occupations.

Our contention is that the process has now gone into reverse to the extent that technology is enabling new skills to be created, re-integrating older skills. The success of 'primary' automation (in terms of the two categories discussed above) has led to a position in many areas of work, where capital intensity is such that capital costs have far outstripped labour costs as a contingency of competition. In these circumstances, it becomes advantageous to retain workers rather than seek ways of eliminating them, and to maximise the skill-profile. If 'secondary' automation is introduced, with small batches, higher quality, and greater diversity, this becomes almost imperative. This analysis concurs with that of Piore and Sabel (1984) and other advocates of the flexible specialization theory. Their specific view is that 'industrial divides' occur (very infrequently) where the industrialized world is able to choose between craft or mass production skill/market strategies. Such a divide, they contend, occurred towards the end of the nineteenth century, with mass production on the Taylorist/Fordist model being adopted. Another such divide is said to be offered by the coincidence of differentiated markets and flexible technologies in the 1980's.

This view has called forth considerable opposition from adherents of the 'de-skilling' explanation of work-organisation, whether neo-Marxist, post-Braverman, or independents. The new school is original not least in that it offers a perspective whereby labour can turn flexibility to its own advantage, whereas elsewhere it has generally been regarded as a synonym for the destruction of demarcations, skills, workplace rights and even trade unionism. To many labour-theorists (for example, Smith, 1984) technology and its imperatives constitute the smokescreen of 'mystification' behind which management strategies for the subjugation of labour are concealed. This, as we have seen, is fully in line with the preceding Smithian (1776) conception of the strategy (division of labour) preceding technology, which this serves as its mere extension. The 'flexible specialization' theorists would argue in return that the choice currently available to management is weighted towards the option by which it would be in their own interests to

increase and develop the skill-input of workers. There is another level of argument, however. As the work of Cross (1985) has demonstrated, (parallel to our own), the new technological flexibility may up-grade certain categories of workers; the shift to a multi-role/multi-disciplinary craftsman is a «reflection of the general shift from a differentiated and specialist based organization to an integrated one» (1985; p. 203).

Although clear in the case of the younger and more broadly-trained craftsmen, the sift is not beneficial to all categories. It can lead to new forms of skill polarization not only in the plant, but also at the societal level. When we find that the average skill-level in a plant has increased, this has as much to do with the fact that semi- or unskilled workers have been largely eliminated, a loss only partially offset by an increase in the number of highly qualified specialists (who may in any case soon be facing the same pressure as the craftsmen to broaden their skills or become obsolete). At the macro-level, this may lead to the development of a rigidly two-tier society, based on a distinctly developed dual labour-market, with a significant underclass forming below the level of the professionals and skilled workers who will along form the 'core' of productive employment. The underclass may either be exported (as in the case of many *gastarbeitern*) or pushed to the periphery of insecure sub-contracting, part-time employment, poorly-paid and unregulated service-work, or unemployment.

On the political level, 'flexible specialization' appears to fit into the split between different branches of the left. Whilst anathema to the 'hard left' in that it conceives of a 'beyond the zero-sum' approach to workplace relations, with mutual benefits for management and workforce, it appeals to the 'soft' left in their search for newer and wider alliances on which to base electoral strategy and industrial and economic policy. Piore and Sabel's (1984) chapter on 'yeoman democracy' represented an attempt to recast the socialist vision, reconciling it with traditional American liberalism and individualism. Detractors are quick to emphasise that this is a form of socialism that may easily co-exist with a two-tier society.

The implications for trade unionism are potentially very significant. On the one hand, the increased polarization of the 'working class' threatens the conscience as well as the rituals and alliances of the movement, whether or not flexible specialization represents a compromise with these trends. What is clear without doubt from the above authors' account of industrial strategies in Germany over the last hundred years, is that at each juncture where strategies rooted in a high emphasis on craft-skill had the upper hand, the labour movement as a whole was a retreat, with the exception of the craft workers' (often unofficial) organizations, and whenever mass production was the order of the day, it was the craft workers who lost their

position, whilst the general unions regained theirs (1984; p. 143-151). On the other hand, in a country like Britain (where, alone amongst the major industrial nations, the 'crisis of mass production' has been super-imposed on an already-existing relative, and later absolute decline as a manufacturing economy) those amongst trade unionists who have criticised the inappropriateness of management strategies (such as an overweening concern with labour productivity as opposed to quality, design, training) are likely to welcome a strategy which undermines the more destructive national traditions. In practice, however, trade union approaches are, inevitably, reactive, and will pivot around whether or not their members' skills and jobs are threatened or enhanced.

The debate over 'flexible specialization' has increasingly emphasised the particularity of British conditions. A recent international conference on technology and skills (EGOS, 1986) produced a large number of papers by European authors of whom the general outlook was optimistic. To counter this trend, two British academics delivered papers supporting the Braverman de-skilling thesis and dismissal that of flexible specialization. When they confessed themselves to be pessimists, a member of the audience retorted «not so much two pessimists as two Englishmen!»

On this occasion, something of a compromise was reached whereby both de-skilling and flexible specialization were accepted as organizational paradigms placed on a continuum, so that they were present in all organizations to a differing extent and at various times.

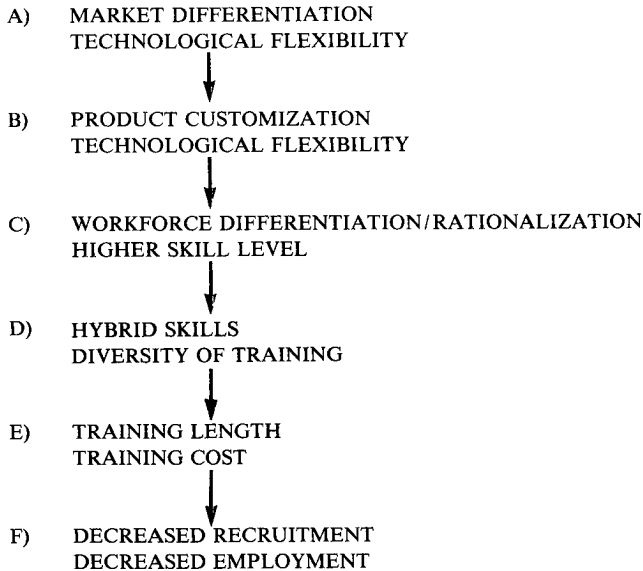
A SIX-STAGE MODEL

In order to show how technology and skills-changes may be more clearly explained in the context of ever-increasing applications of microelectronics, we would like to introduce a six-stage model, which has emerged from our ongoing research, (see Campbell and Warner, 1987b). The investigation covers a sample of British firms, described elsewhere in greater detail.

According to this proposed model (which develops an earlier version — see Warner, 1987), six separate stages of a process linking technology with a set of human resources variables may be extracted (see Figure 1). The phenomena have been grouped together where (particularly with A and B) it is difficult to assign precedence or a clear direction of causation.

A) From the mid-seventies onwards, the availability of flexible technology, based on microelectronics, coincides with a crisis of mass production and trend to diversity in the market, as noted earlier.

Figure 1
Changes in Markets, Technologies and Skills
in Period of Slow Economic Growth



B) Flexibility of technology enables the meeting of a wider range of specific customer needs/demands than before. At the same time, as customers become aware of the potential of the technology, they demand a wider range of functions from a given product. As more functions can be encapsulated into a smaller space, through the use of microelectronics, so customers demand that the newly available 'space' in the product be filled with new or more elaborate functions (this is more clearly the case with such electronic products as the telephone exchange, which in the past was much larger and involved complex electro-mechanical controls). With more and more functions enclosed in a small space, the technology, both in hardware and software, becomes increasingly complex.

C) As this process continues, the workforce is 'rationalized'. The removal of many of the production steps associated with electro-mechanical assembly leads to a decline in the number of semi-skilled jobs. Even where no reduction occurs, the proportion of employees engaged in such work will fall, the numbers failing to increase in line with increases in turnover or profits. At the same time, more professional specialists will be recruited to

cover the increasing load placed on design and development. Matrix forms of management and on-the-job autonomy may be introduced. These activities will begin to outweigh production in time, money and perceived importance. In many cases, notably those where product-technology is highly sophisticated, production may be 'hived off' either through increasing buying in of components or through sub-contracting the manufacture of sub-assemblies. A more flexible form of task-organization characterizes this stage of development.

D) As products become more complex the interfaces between different design or production disciplines become more tangled and integrated. A similar development may be encouraged regarding the skills of employees. Professional specialists may need to take more notice of the input of other disciplines or to take more of a 'systems view', with greater awareness of the product as a whole, rather than just their particular contribution. Equally those involved in the assembly, testing and maintenance functions may require a more general understanding than before, and possibly the command of a wider (if not necessarily 'deeper') range of skills which may in turn require regular up-dating. The same is true for specialists, who particularly where computing skills are concerned, may find their knowledge to be obsolete surprisingly early in their career. As a consequence of these trends, employers may need to invest in a wider range of training activities than before. Even if they fail to recognise this need, they may find it increasingly difficult to attract new specialist recruits without providing the 'career insurance' of re-training, at regular intervals.

E) All this should lead to the expansion of the training-function, with a larger amount of investment for a larger number of days per year to be assigned to training each employee. In higher technology companies, as product-technology increase in sophistication more 'state of the art' training, involving close co-operation with academic institutions at all levels, may be needed, all of which will entail greater cost per head, as well as greater 'administrative effort'. Rapid technical advances across several sectors of industry usually lead to skill-shortages and Britain has been particularly prone in this respect. With recruitment of people at many levels of skill becoming a problem, companies may find they have to devote even more resources to developing the skill-base they already possess.

F) Extrapolating from all the above trends (frequently encountered in our field-work), it follows that recruitment of an individual becomes more of an 'investment decision' than before. Fewer people may be chosen, and more carefully. The result may well be a much smaller, more highly skilled workforce in manufacturing, which may have a less than *beneficial*, or even a *negative* effect on rates of employment. Although increased com-

petitiveness by key companies may have spin-offs for employment elsewhere and increase aggregate demand, the evidence for this in Britain is less than encouraging. Viewed as a whole, then, the process (conceptualised in figure 1) suggests that up-skilling and a greater emphasis on training, whilst benefiting a core of workers in industry, may entail increasingly concrete 'caste-divisions' between the above and their 'peripheral' counterparts. *Pace Piore and Sabel (1984)*, it is clear that market differentiation, however it is approached, may not necessarily present an escape-route away from mass unemployment. At the same time, to ignore the changed circumstances, and to persist with outdated methods (de-skilling, standardization, emphasis on labour productivity at the expense of quality and flexibility, economizing on training) can only lead to further economic decline.

INDUSTRIAL AND POST-INDUSTRIAL SOCIETY: CONCLUSIONS

Critics of the 'across-the-board' perspective (and we would place ourselves in this category) have pursued an argument on similar lines when they have perceived conceptions of the 'post-industrial' or 'information' economy as being «less founded on universal facts of evolution», than «historically stable patterns of specific societies» (*Sorge et al, 1983; p. 46*).

Interestingly, such work both hypothesized and found that this preference for either manufacturing or services in Britain and (West) Germany influenced work organization at plant-level. British firms were found to deploy Computer Numerical Control (CNC) machine-tools according to a 'services' logic, (even though they were, of course, engaged in manufacturing). This 'services' logic meant that the technology was introduced and seen in such a way that employment in services, service-related and white-collar sections of manufacturing could be seen as the prime beneficiaries. In Germany on the other hand, such CNC technology was perceived more 'industrially', that is it was placed in a context of craft-traditions.

What emerges from this comparison is a definite cultural, or culturally-rooted difference of perception as to what advanced manufacturing is actually about. In Germany, it appears that it is seen as involving the continuation of traditions of technical craft established over a century earlier. In Britain, although the expressed opinions of the managers concerned did not see it as such any more than did the Germans (1983; p. 187), CNC machines are deployed in such a way as to suggest that they represent a major step away from practical craft-based work and towards white-collar 'informatic' work.

Research taking into account cross-national differences insists on a different view of microelectronics applications. Far from being simply the remover of traditional jobs and skills, replacing them with 'information' skills, microelectronics may be seen «distinctive for making the evolution of 'traditional' skills towards new levels of expertise and contents of work possible» (1983; p. 198). In the next stage of our ongoing research, we hope to show how this applies to product innovation involving microelectronics applications in the above two countries on a comparative basis.

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Les relations du travail, la formation et les changements technologiques au niveau de l'établissement

Cet article étudie d'un point de vue critique les relations en milieu de travail, la formation professionnelle et les changements technologiques en se demandant s'ils sont nécessairement reliés les uns aux autres d'une manière rigoureuse, spécialement lorsqu'il s'agit de microélectronique. Il soutient aussi que de nouveaux métiers apparaissent là où la technologie et des marchés différenciés agissent les uns sur les autres, ce qui a d'importantes conséquences sur les stratégies de formation professionnelle.

Les recherches sur lesquelles il repose se fondent sur un échantillon considérable d'entreprises britanniques dans les secteurs de haute technologie. Ces entreprises recourent à la microélectronique à des degrés divers. Les entrevues ont été effectuées auprès du personnel d'ingénieurs et des responsables de la formation.

L'avènement de la microélectronique dans la fabrication des produits dérivés de l'ingénierie a coïncidé avec une crise dans les marchés des biens et une tendance plus accentuée de la consommation ou de l'achalandage qui a accompagné une plus grande automatisation. Cela a entraîné des progrès comme l'esthétique industrielle (design) qui ont eu comme conséquence de rendre plus complexes tant l'esthétique industrielle que le produit. Aussi a-t-on vu dans la technologie nouvelle un amalgame des deux fonctions qui, grâce à l'automatisation du «design» qui rend la production en petits lots ou en petite quantité plus proche de la production de masse de façon à réduire les coûts par l'intermédiaire d'une spécialisation souple. Une des contraintes majeures des entreprises britanniques a été le manque de compétence dans ce domaine. Trop d'entreprises ont tenté d'engager des diplômés d'université plutôt que de recycler les techniciens déjà à leur service. Le recyclage des diplômés était aussi important. On a découvert que l'utilisation plus considérable de systèmes plus compliqués exigerait des ingénieurs polyvalents et des travailleurs davantage conscients de la qualité du produit.

Les auteurs soutiennent ensuite que l'éducation continue et la formation professionnelle sont nécessaires pour recueillir les avantages de la microélectronique. Les auteurs ont poursuivi leurs recherches de manière à en voir l'impact sur les compétences pour conclure que les théories tendant à diminuer la qualification professionnelle (de-skilling) sont d'une approche trop simpliste, tout autant que le mirage d'une usine totalement automatisée où il n'y a pas de travailleurs. Ce qui peut se produire relativement à la qualification professionnelle est le résultat d'un processus politique en milieu de travail par les progrès et les reculs des dirigeants et des travailleurs pour exercer le contrôle.

L'article étudie les liens entre la technologie et la division du travail, ce qui amène les auteurs à considérer que les qualifications professionnelles sont rehaussées plutôt que diminuées par suite des progrès de la spécialisation flexible et de la technologie. En Grande-Bretagne, certaines entreprises ont eu tendance à réduire les qualifications, mais la volonté de faire une trouée dans des marchés différenciés a conduit les entreprises progressives à recourir aux travailleurs qualifiés lorsque la qualité plutôt que le niveau des prix devient de première importance.

Le niveau de qualification moyen dans les usines peut s'être élevé, mais ceci s'est produit aux dépens des travailleurs moins qualifiés et signifie qu'il se trouve plus de personnes à l'usine dans les catégories de postes de haute qualification. L'article analyse également les conséquences que cette situation peut avoir sur le syndicalisme. Les syndicats réagissent et ces réactions consistent à se demander si les emplois de leurs membres sont menacés ou augmentés. Enfin, un programme en six étapes relatif aux changements en matière de technologie et de qualification a été mis au point pour le milieu de travail de façon à relier les marchés, la consommation et la différenciation avec des qualifications polyvalentes ou hybrides pour les mêmes travailleurs, les coûts de réadaptation professionnelle et le recrutement du personnel.

L'article traite finalement de l'effet qui peut résulter de ces transformations sur les emplois semi-qualifiés et sur l'augmentation du nombre d'hommes de métier et de techniciens qui ont une formation à plusieurs volets. Une forme plus souple d'organisation du travail peut accompagner la situation nouvelle par l'introduction de groupes de travail et de structures qui peuvent servir de modèles. Les disciplines de formation professionnelle peuvent devenir plus interreliées et intégrées. En conséquence, le rôle de la fonction de formation devient aussi plus importante.

La conclusion que l'on peut tirer de cette enquête à l'échelle nationale vise à montrer jusqu'à quel point ces tendances s'appliquent à diverses sociétés avancées et si les formes d'organisation en milieu de travail reposent sur des bases culturelles plutôt que déterministes dans les économies post-industrielles.

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